

# The Sidereal Messenger.

Conducted by WM. W. PAYNE, Director of Carleton College Observatory,  
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"In the present small treatise I set forth some matters of interest to all observers of natural phenomena to look at and consider."—GALILEO, *Sidereus Nuncius*, 1610.

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VOL. 2. No. 10. JANUARY, 1884. WHOLE No. 20.

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## THE RED SUNSETS.

BY THE EDITOR.

For the last two months and more, varied and most brilliant sunsets have attracted the attention of foreign observers, and full notes of these extraordinary phenomena have appeared in the current numbers of their scientific periodicals. A few citations from *Nature* and *Knowledge* must suffice for our present purpose.

Dr. J. Arnold saw the *Sun* as a blue globe, Sept. 2, and after dark thought the town on fire from the brightness of the sky. September 10, 11, 12, W. R. Manley, of India reported that the *Sun* was dimmed by haze, and, as having a decidedly greenish-blue tinge. From Nice, Nov. 15, information came to Mr. A. C. Ranyard, of England describing extraordinarily beautiful sunsets at that place during the month of October. The most important fact noted was that "colored twilight lasted much longer than usual. Captain Noble, of England speaks of similiar observations and says in *Knowledge*, November 8: "The whole western sky was ablaze with the most vivid crimson glow; albeit the *Sun* had set for an hour and a half."

Enough has been given to indicate something of the extent and unusual appearances of recent sunsets in foreign lands. The same thing has been seen in the United States.

They were not observed so early doubtless, because the months of October and November were so mild and temperature so high comparatively, as to lead persons to expect such phenomena especially in the West where beautiful sunsets are common in autumn months. As the colder days of last month came, and the brilliantly crimson sunsets continued common observation noticed them, and they have become the theme of universal admiration and everybody is asking the cause of such displays.

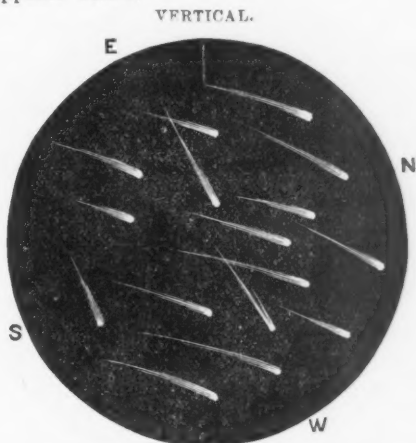
The last noticed by the writer was December 20. The sky was overcast with thin clouds apparently motionless, and about 4 o'clock in the afternoon, the whole western sky was lighted up with a mellow golden hue that gradually intensified towards the *Sun* that was sinking in the low bank of clouds just above the horizon. As the *Sun* disappeared, the play of light, in crimson and gold, penciled upon the clouds the most exquisitely beautiful piece of fret-work that ever met the writer's gaze. As moments passed, the picture was so changeful that it is vain to attempt a description of it. The noticeable feature that this light display should extend nearly to the zenith a half-hour after sunset time was most remarkable.

It was fully two hours after sunset that the last traces of its glory disappeared.

As to the cause of these strange phenomena there are various opinions given by astronomers, some of which seem highly probable. At this time we mention one, reserving others for later consideration. That to which we now refer is very briefly indicated in a letter from Professor WILLIAM R. BROOKS, Phelps, New York, under date of Dec. 8, 1883. He says: "While sweeping on the evening of November 28th, it was my pleasure to observe a wonderful shower or flight of telescopic meteors about ten degrees above the horizon, and near the sunset point. They were very small, none of them visible to the naked eye, most of them leaving a faint train, visible in the telescope for one or two seconds. The motion of most of them was to the northward, with an occasional group to the south of the *Sun*, moving southward.

This observation occurring at the time when the unusual red light phenomenon was at its height the theory is suggested of a possible connection between that phenomena and the passage of the *Earth* through a mass of meteoric matter more or less attenuated."

Being deeply interested in the very remarkable observation, Professor Brooks was requested to give a drawing of what he saw which was kindly furnished for the MESSENGER and appears below.



FLIGHT OF TELESCOPIC METEORS, TELESCOPIC VIEW,  
ERECTED. [BROOKS.]

Under date of Dec. 15, he further says: "As may readily be inferred, the wonderful sight is a difficult one to represent in a drawing; but I have endeavored to give some idea of the appearance at its maximum stage. The instrument used was my nine-inch reflector with comet eyepiece giving a field of one and one-half degrees. The field shown in the drawing was a few degrees north of the sunset point and about ten degrees above the horizon. The faithful comet seeker, frequently in a single night's work encounters numerous telescopic meteors, singly, very rarely two at once; but this flight is quite unprecedented in my experience."

MR. E. E. BARNARD, Nashville, Tenn., has given attention to these wonderful, and as he says unaccountable phenomena. His first notes were made Oct. 29, and since that date, glowing sunsets have been seen quite constantly when the sky was favorable. From observations which cannot now be given, he thinks the cause lies in the upper strata of the atmosphere, though not at all certain of it. He confirms the observation first reported by Professor BROOKS.

As late as Dec. 15, he saw with the telescope small bright bodies close to the *Sun*. They were visible at the rate of five or six per minute, and were all moving to the north of east quite rapidly. Occasionally a larger body was seen to flash across the field, blurred by being out of focus. Generally they looked like little stars, many as bright as those of the first magnitude. Mr. BARNARD could follow the slower moving ones with the telescope for five or six degrees from the *Sun*, where they became faint and were lost. He was unable to detect any crossing the *Sun*; they seemed to be some distance from it, and required generally an increase of focal distance to see favorably. He thinks they are small particles drifting with the air currents at considerable altitude. He gives no definite opinion concerning the cause of the red sunsets.

The subject of cosmic dust in the atmosphere is one of great interest as related to meteorology and astronomy, and to its study, by astronomical observation and physical experiment, has been given more attention during the past few years than in all time before. It is now known that there is scarcely a night in the year in which meteors are not seen. Usually these bodies move through space in swarms or trains, some of which are large, others small. The meteors themselves vary in size, from the finest dust to the *bolis* of several tons in weight. Space is so filled with this matter that some train is doubtless rushing through the *Earth's* atmosphere constantly, for astronomers think that over seven hundred of these meteoric streams annually pass in close proximity to the *Earth*, while traversing their own orbits about the *Sun*.

(To be Continued.)

## THE TOOLS OF THE ASTRONOMER.

PROFESSOR M. W. HARRINGTON, ANN ARBOR, MICH.

*(Concluded from page 268.)*

To overcome errors of aberration the device of lengthening the focus was resorted to until telescopes one hundred feet long were not uncommon and they reached a length of 300 feet. The difficulty of management of such giants was very great. The observer must be accompanied by a large squad of laborers and much time and patience was required to get the instrument in position for observation. For better definition the eye-lens was divided thus making the compound eye-piece of modern times. To remedy the defects of aberration another device was discovered upwards of a century after the advent of the telescope. Advantage was taken of the differing refractive and dispersive powers of various sorts of glass. By ingenious combination of crown and flint glass the achromatic objective was made, and this rendered possible the reduction of the telescope to a manageable size, while giving a better image of the object viewed. Since then the development has again taken place in the direction of size, until we now have promise of a lens three feet in diameter—a size already equalled by Tschirnhausen, however, nearly two centuries ago.

The origin and development of the reflecting telescope is parallel with that of the refractors. Its principles go back to Ptolemy and Archimedes, but first appeared as a telescope about the middle of the seventeenth century and took definite form in the latter half of that century under Gregory, Newton and Cassegrain. Its capacity was more completely sounded by Sir Wm. Herschel, who in the course of his life made 400 of them. A professional musician, he seems to have been directed to the reflector by the ease with which he as an amateur could construct them. So interested did he become in their construction that 'tis said that he would not spare time for his meals, but was fed by his sister Caroline, while seated at his lathe. 'Twas with this

form of the instrument that he sounded the heavens and laid strong and deep the foundations of stellar astronomy.

With the advent of the telescope came at once an immense increase in the body of astronomical facts, of itself, by bringing bodies optically nearer, it rendered many visible which were before unseen, and gave new facts concerning those already known. Combined with the principles of the astrolabe it made the mural circle and transit instrument. With this triumph of optics came new studies and large developments in that field. To accelerate the computations necessitated by the rapidly growing mountain of observations logarithms were invented. The facts as they accumulate strengthened on all sides the speculations and deductions of Copernicus and Kepler, and Descartes in attempting to improve on these theories invented a new geometry.

One of the capital inventions following directly on that of the telescope was the micrometer. Under its manifold forms there is one leading idea,—the comparison of the telescopic image of a heavenly body with a means of measurement placed within reach of the hands. For this purpose the measuring apparatus is placed in the principal focus of the telescope, and its image enters the eye with that of the star so that they appear to be together. It is a small instrument; I could conceal it in my pocket, almost in my hand, yet it permits a minuteness of measurement almost magical. To be seen with the naked eye an object must subtend an angle of a minute of arc, but with this instrument we can easily determine a second, be sure of its tenths and even discuss its hundreds. It is this delicacy of measurement which has rendered possible that great and abstruse branch of astronomy which discusses perturbations—a department which has occupied the brightest minds which the world has seen,—Newton, Euler, LaGrange, Laplace, Poisson, Plana, Encke, Bessel, LeVerrier,—and which has led, not to the invention, but certainly to the chief extension of that great logical instrument of science, the infinitesimal calculus. On the micrometer depends almost all minute measurements, and on them depend not so much

the foundations of the great structure of astronomical knowledge, but rather the fineness of the workmanship, the perfection of the joints by which the stones fit into each other.

The events of a day of manhood often out-number those of a year of childhood, or of all the years of infancy. In this time of the beginning of manhood of astronomy, a single century contains more history than an entire period before. To this century belongs the discovery of the valuable properties of the pendulum. The account of the discovery of its isochronism—*anecdotal perhaps and yet bearing evidence of foundation in fact*, is as follows: Galileo, a medical student of nineteen, was in the cathedral of Pisa, when, probably wearying of his devotions he dreamily fixed his eye on the beautiful lamp hanging from an arch. It had been drawn one side to light and was now swinging from side to side. Though the distance to which it swung back and forth grew steadily smaller, Galileo had time to note that the time of the swing remained the same, a fact of which the young medical student convinced himself by feeling his pulse. A little thing that,—if it had occurred to a little mind as it undoubtedly had occurred myriads of times in myriads of ways, nothing would have come of it. But the observant mind of Galileo seized on the fact, and the isochronism of the pendulum, which nature had lavishly displayed from the time of the first spider swinging on his thread was at last discovered. For discovery two things are required, the phenomenon and attention, and the rarer of these is attention. Nor did Galileo let the matter rest there, he followed it up to an application which was then of much interest to him, namely an instrument for counting the pulse.

But just as the discovery of the refraction of light did not make a telescope, so that of isochronism did not make any of the instruments which depend on it. One of its chief applications is to the regulation of the clock. Galileo was much interested in the determination of longitude at sea which was one of the most urgent practical questions of his day. He spent much of his last days in pursuit of

the subject and not long before his death the idea of the application of the pendulum to this end occurred to him. He called to him his son Vincenzo and gave to him the necessary ideas with drawings, but before they could be executed he passed away. His son is said to have worked on his father's ideas but he took so much time to it that death called him away too before he could finish the construction.

Let us stop for a moment and see just what the requirement is. Here we have a continuous force, a weight over a pulley, then a pendulum beating seconds, but rapidly brought to a stand still by the least friction or other work to be done. If we attach weight alone to the wheelwork the clock rapidly runs down, if pendulum alone it cannot do the work and soon ceases to beat. The weight must keep wheelwork and pendulum going, the pendulum must keep it from going too fast. How can we combine the steady pull of the weight with the delicate and regular touch of the pendulum, and have it return enough of this touch to keep the pendulum in motion? It is done by an ingenious device called the escapement and I do not know where the thoughtful man can find a better illustration of unity of purpose with variety of means than in the manifold forms of this instrument. 'Tis worth any one's while to watch the escapement of any time-piece when it is going, but to see the acme of ingenious adoption of means to ends, combined with exquisite simplicity one must climb to some turret clock and see that delicate little contrivance which serves to drive a heavy pendulum without checking it and to at the same time hold back the hundreds of pounds of the weight.

But the pendulum is not alone of use in the clock. It is the chief instrument for the investigation of terrestrial gravity, with it as a horizontal instrument Cavendish weighed the *Earth* against a pair of lead balls; with it as a vertical swinging body Airy weighed the *Earth* below the bottom of the shaft of Hatton colliery against the shell outside. By it we investigate the general figure of the *Earth*, the variations of its surface from the geometrical figure and the smaller motions of its surface which when

larger we know as earthquakes. It shows us that gravitation depends on mass and not on constitution, and affords us an accessible and reliable unit of measurement. It is a small and simple instrument, but so versatile that it is one of the most important in physics; only a ball hanging on the end of a string and yet with it we weigh the *Earth*; mark out its figure with all its variations from regularity, check off the speed of *Saturn* and *Jupiter* in their race and time the universe. Insignificant as it appears it is a worthy rival of the telescope in usefulness.

But while the pendulum gave the vertical, it was not readily and easily available for measurement of horizontal angles. Theory had brought the science to a point where a more accurate knowledge of the *Earth's* magnitude was required, and this could only be got by the measurement of horizontal angles. The essential step towards the new method of leveling was the discovery of Thevenot, in 1660, of the spirit-level, more properly at first a water-level.

And here culminated, for that age, the invention of new ideas for astronomical instruments. The next century and a half was spent in combining and improving them, and in working out the secrets of nature, which they laid open to us. Thus we had the astrolabe typifying instruments for coarse angulation; the telescope; the micrometer for minute angulation; the pendulum and spring balance for time-measurement; the spirit-level for location of the horizontal plane. These can be combined in various ways: thus,

Telescope + circle = sextant, octant, etc.

Telescope + circle in Equator + micrometer = equatorial.

Telescope + circle + level + micrometer = transit theodolite, etc.

All these various forms of instruments had been invented before the end of the seventeenth century. As their result, we find astronomy in the next century assuming its present form. As direct result of the great accumulation of facts, we have the great deduction of universal gravitation and the great speculation of the nebular hypothesis.

The word for advance was passed along the entire line of

science. Observatories were founded and supported by princes, governments, and institutions of learning. The earliest observatories were temples; then came the public observatories in the city and the court of the academy. Under Mahometan princes, observatories were founded at Bagdad, Damascus, Cairo, in Persia, from the beginning of the ninth century. The one at Bagdad was in the palace-garden, that at Cairo, on a hill east of the city, which hill was presented by the ruler for that purpose. Not until late in the fifteenth century did these temples of celestial learning find a home in Europe. About 1470, a wealthy patrician of Nuremberg, Bernard Walther by name, founded the first, placing it under the charge of the astronomer Regiomontanus. Nearly a century later, William IV, of Cassel, had an observatory built on a tower over one of the gates of that city. The historian of the city tells us that the uppermost rounded part could be turned, so as to be directed to all parts of the sky. Evidently we have here a revolving dome, so that the characteristic feature of an observatory is about three centuries old. A few years later, Frederick II, of Denmark, gave Brahe an island two or three miles long, and built on it what is the most celebrated of the ancient observatories, to which Brahe gave the name Uranienburg, or sky-mountain. A friend of Brahe had written to Frederick, recommending him as a man destined to do great things in astronomy, and advising the prince's patronage. "Your Majesty would thereby gain an immortal name and do great good to your subjects," wrote he. To some this might seem strong language, but it did not prove too strong on this occasion. Uranienburg was the birth-place of modern astronomy—the place where those observations were taken, from which Kepler worked out the laws which make the basis of the science. And who was this Frederick II of Denmark? A king! Very likely, but there have been a great many kings, all sorts of people, good, bad, indifferent, some worth remembering, the most not. Who was he? The Encyclopedia Britannica knows him not. Perhaps he had some petty warfare; there have been a good many; perhaps through him a few people have been killed.

Many billions of them have lived and died, and if he had a hand in the taking off of any, it is now forgotten. Indeed it is true that his patronage of Brahe and the construction of Uraniberg, have given his name immortality. The preparation of the birthplace of modern astronomy is somewhat unique; but one king could have a hand in it, and to that king it has given immortality. The number of observatories was from this time slowly increased until the beginning of the present century, when it began to grow rapidly. At the present time there are about one hundred and fifty where observations of sufficient importance have been taken to make it worth the while of the astronomical annuals to publish their positions. Of observatories, public and private, where there are anything but the smallest instruments there are probably not seventy-five in the United States, and 500 would fully cover all worth mentioning in the United States. There is abundant room for more, and there is need of a working observatory.

But though invention was resting it was not barren. Less than fifty years ago, it awoke and its activity has resulted in a short list of new instruments, the spectroscope, the photometer, the camera, the polariscope. Some of these had been long known, but were only recently employed astronomically. For the spectroscope only have we probably reached a definite form, in which improvement will be only in details. It is needless to point out what a flood of new facts it has let in upon us that is recent and familiar history and the flood still continues unabated. Moreover, the active pursuit of this new branch has aroused interest in the corresponding part of physics and chemistry and given rise to new developments in them.

And now what conclusions can we draw from the development of astronomical instruments. They have been developed gradually; from the germ to the developed species extend one or more historical eras. The best have survived and gradually adapted themselves to their changed requirements and surroundings. An apparent sudden development is really only a readaptation of an old idea.

A curious law in the development has been a tendency

always to grow in size, and this growth in size has always ended in failure, or rather in the large being replaced by smaller instruments. The Gnomon culminated in that of Samarcand, which was 165 feet high, higher than most steeples. The astrolabe, culminated in the sextant of Brahe made at Augsburg and having a radius of twenty feet. The repeating circle of to-day one could put in an overcoat pocket. The old telescopes grew to be 100 feet long and more then, with the discovery of achromatism, fell back to small dimensions. They are again creeping forward to the size of unweildy giants; let us of small purse and shallow pocket hope that they will again fall back until they are within our reach.

But the plainest fact which comes out in our survey, (if I have succeeded in my purpose,) is the absolute and direct dependence of the noblest of the sciences on her instruments. Our proposition is; *that in the progress of astronomy the instrumental art has led the science and has also led advances in the sciences nearest allied.*

We could reach the same conclusion by another course of procedure. We could take up a list of the triumphs of astronomy and see if they did not lead us directly back to some instrument of special excellence or novel character. Thus aberration of light is due to an unusually large zenith-sector which Molyneux had made for another purpose but which he intrusted to Bradley. The first of the asteroids was due to the possession by Piazzi of a masterpiece of Ramsden's vertical circles. This led Piazzi to devote himself to star work in the course of which the planet was found.

But why continue the list. This is not the time for a dictionary, nor for a catalogue. Indeed our thesis is so self-evident that when we approach it properly it needs no defense; we cheerfully acknowledge it. From it I had proposed to draw an apology for observatories in general and this one in particular, but your thoughts have already forestalled me. I can only add the idea that each instrument requires a man behind it, to do its thinking for it. It cannot think for itself. Without the working astronomer it is

but so much glass and brass and iron, worth a few cents a pound; with him it is capable of doing wonderful things.

We noted in the beginning the fallibility of the judgment and the necessity of submitting it to the test of the foot-rule. Let us now note, and in conclusion, that this foot-rule is itself the invention of that same human mind; that the crutch the judgment employs to walk with is its own work. The strength to do all things without help is one thing and a desirable one; the strength to find out its own weakness to invent and supply the aids it requires is another and a greater.

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#### COMET "B" 1881.

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BY THE EDITOR.

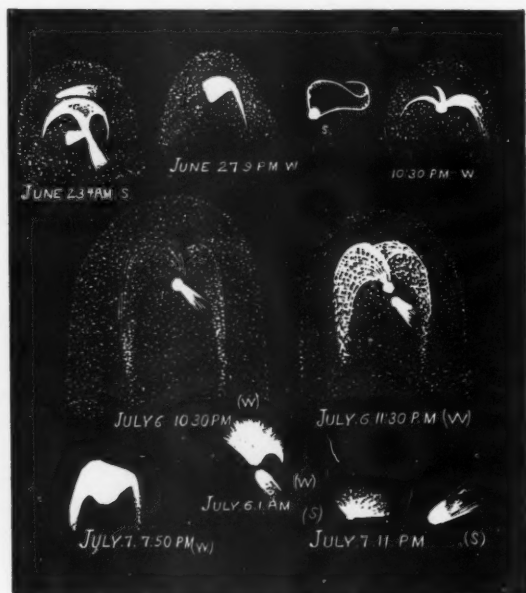
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It will be remembered that a spirited discussion sprang up in July of 1881, about the division of the nucleus of comet *b*, Professors STONE and WILSON, of Cincinnati claiming that the nucleus separated into two parts July 6, 11<sup>h</sup> 30<sup>m</sup>, while other able observers held that no such view had been seen by them although they had been very watchful.

We present herewith some drawings of the wonderful changes that took place at the times indicated. We are not aware that these drawings have been published before except by the *Minnesota Academy of Natural Sciences* and by Professor H. C. WILSON, acting director at Cincinnati in a late report of observatory work. It was by kindness of Professors STONE and WILSON that we were permitted to use their notes and drawing some time ago. The following was taken from the notes of these observers:

"That of June 23 is the first sketch we made, and gives only the most prominent features of the coma. On the 27th of June, some remarkable changes took place in the appearance of the comet. The second drawing represents quite faithfully its appearance (says Mr. WILSON) when I first went to the telescope. The fan was very bright, one-sided, and almost right angled on the left." Professor STONE's representation in outline is seen next, in order, in

the cut and is designated by his initial. It shows the fan with nearly right angled opening at the coma, but it is suddenly re-curved on itself, and twisted about like a whip-lash. Later the corner which formed the right angle seemed to move upward, and a new jet was formed from it; nearly as bright as that towards the right hand, but shorter. Then another jet formed towards the left, quite faint, and nearly as long as the one on the right. Later, Professor STONE made a note that the middle and left hand jets grew brighter, while that on the right hand nearly disappeared. The drawings for July 6, are the most singular, and were made by Mr. WILSON, Professor STONE making the micrometric measurements with him.



COMET "B" 1881.

The first figure in the middle of the cut gives the comet as WILSON saw it at 10<sup>h</sup> 30<sup>m</sup>, July 6, Cincinnati M. T., before the separation was distinctly made. The next figure shows

the division of the nucleus, as seen by both observers at 11<sup>h</sup> 20<sup>m</sup>, on the same night. By micrometrical measure the distance between the two parts was six seconds of arc. At 1 o'clock, strong illumination was given to the field of view, and the appearance of the nucleus in the telescope is shown in the lower figure. The measure between the divided parts was again taken, and the distance, at this time, was ten seconds of arc. July 7, (the lower figures) shows the appearance of the fan, under illumination from 7<sup>h</sup> 50<sup>m</sup> p. m., till midnight. There can be no doubt, but that a tremendous commotion was going on in the nucleus of this comet during these observations. The comet was about thirty-seven millions of miles from the *Earth* at this time; if so, a second of arc, in linear value, would be about 1,000 miles. Then imagine the nucleus of a comet having the volume of a large planet, suddenly rent into two parts, and violently thrust assunder from each other, from 6,000 to 10,000 miles in one hour of time, and you have a display of celestial fireworks passing all human comprehension.—*Bulletin of the Minnesota Academy of Natural Sciences.*

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*The Common Theory of the Solar Corona with a Statement of DR. C. S. HASTINGS' Objections.*

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[The following definite statement of the theory of the solar corona, as held by astronomers and physicists generally will be read with profit. The objections are forcible, and show exhaustive study. The extract is taken from the report of Dr. Hastings to the National Academy of Sciences, recently held at New Haven, Ct.—ED.]

The *Sun* is surrounded by an atmosphere of incandescent gas, chiefly of the substance which in the spectrum is called the 1,474 K line, and of hydrogen, extending to a height of not less than 600,000 miles above the photosphere, and probably, according to Stone, a height of more than double those figures. Mixed with this atmosphere, i. e. suspended in it, is a large quantity of solid or liquid material which is at such a temperature as to be self-luminous. It is this which yields the continuous spectrum free from dark lines. Be-

isides these components of the envelope, there is present matter which reflects or diffuses light much as our own atmosphere does. To this is attributed the partial radial polarization of the corona. The streams and rifts in the corona indicate matter repelled in various quantities from the *Sun* by forces which may be electrical. This neglects no one of the established features of the corona and has apparently contented most writers. It is essentially the explanation given by Professor Young in his work on the *Sun*, though he does not fail to note grave difficulties in the way of its complete acceptance. When, however, the theory is asked for a quantitative agreement with observation, it utterly breaks down. Some of the assumptions involved moreover are so exceedingly improbable that the mind refuses to accept as even plausible a hypothesis resting on them. Others equally as essential to the theory are absolutely negatived by observations. For, in the first place, the spectrum demonstrates that the gaseous pressure at the limit of the chromosphere is very small, probably far less than that of an inch of mercury. This supposition requires that the pressure of the assumed atmosphere from 600,000 to 1,200,000 miles deep shall be thus inconsiderable, notwithstanding the fact that the force of gravity is more than twenty-seven times as great on the surface of the *Sun* as at the surface of the *Earth*. Though this consideration renders the assumption of a gaseous atmosphere highly improbable, there is a still stronger objection in the motion of comets. All optical evidence of the existence of our own atmosphere ceases at a height of about forty-five miles; still the density at more than twice that altitude is sufficient to offer a resistance to bodies moving with velocities averaging fourteen times that of the *Earth* in its orbit, such as to render them incandescent almost instantly. Now the illumination of a particle in the corona is not indefinitely greater than that of our own atmosphere, the ratio being that of the angular area of the *Sun* as measured from two points. It follows, then, that the density of a visible atmosphere near the *Sun* cannot be indefinitely less than that of our own at forty-five miles from the *Earth*. But there is the clearest evi-

dence that far within the limits of the corona the density must be almost infinitely less than that of our atmosphere at even sixty miles above the *Earth's* surface. For the great comet of the last year passed at a distance of 300,000 miles of the *Sun*, and therefore deep within the assumed coronal atmosphere. This comet traversed the intercoronal space for several millions of miles with a velocity of 180 times that of the *Earth*, not only without being stopped and precipitated upon the surface of the *Sun* but even without having been checked in the least. This was proved by the fact that the orbit derived from the observations after perihelion passage was sensibly the same as before the passage. Still more conclusive proof is offered by the comet of 1843, which passed still nearer the surface of the *Sun*. It is true that its orbit before and after perihelion passage did not admit of such comparison as that of last year. But every law of probability forbids the assumption of a higher velocity before nearer approach to the *Sun* than that due to a parabola. Surely no more decisive argument against the existence of an atmosphere extending as far as the perihelion distance of either comet could be imagined. But the assumption of an extensive atmosphere leads to a contradiction to our experience wholly independently of such considerations which would render it untenable. According to theory as well as observation, the upper limits of the gaseous envelopes of the *Sun* ought to be ordered according to these densities. The material which produces the 1,474 K line, and which may always be seen in the chromospheric spectrum, is according to this criterion as unmistakeably denser than hydrogen as is magnesium vapor, or iron vapor; but if we accept the coronal spectrum as evidence of the existence of an atmosphere, we are, by exactly the same principle, driven to the conclusion that the 1,474 K material is far less dense than hydrogen. The contradiction could not be more abrupt and inexplicable. There are other arguments of not inconsiderable weight which are opposed to the supposition of a coronal atmosphere.

First, the photographs indicated what may be styled a *flat* arrangement of the corona, as though the forces which

produce its irregularities act only in a plane at right angles to the line of vision. That is to say, the rifts and streamers seem to have their origin at or near the limit of the *Sun* and are often narrowly limited in width. Such a character might well exist if the corona were determined by the *disk* of the *Sun*, but would be highly improbable if it were distributed about the solar globe.

Secondly, we are compelled by this theory to assume most improbable changes in the hypothetical atmosphere. For example, the line 1,474 K was traced to a distance of 1,200,000 miles from the *Sun* in 1874, while four years later it was so feeble as to have eluded all but two of the observers, notwithstanding that the conditions of vision were probably better then than ever before. If the line demonstrates the existence of an atmosphere it demonstrates also inconceivable changes in it. In regard to the matter which emits the white light, our statements must be a little less positive. That it is not of solid or liquid particles suspended in an atmosphere after the nature of our clouds is pretty evident from the necessary rarity of such an atmosphere. It is perhaps worth noting that whatever argument can be drawn from the independence, the supposition that a large quantity of meteoric matter is falling into the *Sun* offers almost as great difficulties. We must conclude that it is falling nearly vertically downward in the immediate neighborhood of the *Sun* because the necessary orbital velocities to check the precipitation could not exist within an atmosphere, even if we disregard the difficulties in the way of accepting a theory which implies a swarm of satellites whose orbital poles are distributed uniformly over the heavens. Hence there must be a continuous supply from without. This supply cannot come from parabolic comets, unless those of small perihelion distances are more abundant than those of great. The polarization, when considered quantitatively, is even more incompatible with the accepted theory than either of the phenomena previously discussed. It is clear, as has been pointed out by a number of writers, that the polarization of light reflected from a particle at the surface of the *Sun* is *nil*, because the

luminous source there is a surface with an angular substance of  $180^\circ$ . It is also easy to see, therefore, that the polarization of the coronal near the limb of the *Moon* must be small even if all the light is diffused by matter in such a state of subdivision as to give a maximum effect. At a greater distance from the *Moon*, the percentage of polarization should be greater. But this is quite contrary to the observed law. Again the polarization must, if due to a reflection by an atmosphere, increase continuously with increasing distance from the *Sun*. That it does not do so is established beyond question. The only imaginable explanation for this is the admixture of increasing quantities of non-polarized light at higher altitudes (which cannot be admitted) near the *Sun*. The final assumption that the coronal streamers are formed by a matter repelled from the *Sun* is objectionable, on account of what it implies. Since the rifts are often many times darker than the streamers, it follows that nearly all the white light come from such ejected matter. Moreover, since the material does not give the solar spectrum, it is not bright because illuminated by the *Sun*, but because it is self-luminous. Allusion has been made to the extraordinary arrangement of the streamers, as though confined to a plane at right angles to the line of vision.—*N. Y. Tribune.*

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#### NOTES ON ALGOL AND BETA CAPRICORNI.

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E. F. SAWYER.

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The following chance observation of *Algol* at minimum may be of some interest to observers. I have for several years made it a point to glance at *Algol* on every convenient occasion, for the purpose of seeing this star, when I should be fortunate enough to catch it in faint light. On the evening of Nov. 28, this opportunity was mine for the first time. At  $6^h 55^m$  and  $7^h 20^m$  *Algol* was found to be very near its minimum; or about three or four steps  $> \rho$  *Persei* and four steps  $< \beta$  *Triangulii*, so that a minimum must have occurred near  $7^h \pm$ . This shows how little chance an

observer has of catching stars of this class at their minimum, by only casual observations of them.

The remarks of Mr. E. E. BARNARD respecting the occultation of  $\beta$  *Capricorni*, in the last number of MESSENGER have much interested me, as the occultation was observed at Cambridgeport, and the same phenomena recorded. As stated  $\beta$  *Capricorni* instantly disappeared, but the seventh magnitude star preceding  $\beta$ , lingered something like a second before disappearance, but the phenomena was thought to be due to some irregularity in the *Moon's* limb. However, Mr. BARNARD's explanation may prove to be the true one. In making the observations, the full aperture of my fine clacey equatorial of 4.37 inches aperture was used, and a power of  $80 \pm$  employed.

#### WORLD-LIFE.

Dr. ALEXANDER WINCHELL, professor of Geology and Paleontology in the University of Michigan, has recently published a book entitled "World-Life, or Comparative Geology" which deserves more than the brief notice common to the book-table of this magazine. The systematic and very comprehensive way in which the author has treated most of the important questions of the day that concern equally the sciences of astronomy, geology and physics makes the work a most timely one, and the candor, research and independent thought which have been given to this task are points of excellence that the scientist as well as the popular reader will appreciate.

The book is divided into four parts, treating respectively of (1) world-stuff, (2) paleontology, (3) general cosmogony and (4) evolution of cosmogonic doctrine. In the first part appear studies of cosmical dust and nebular life, treating of meteors, the zodiacal light, comets, the rings of *Saturn*, nebulae, nebular heat, nebular rotation, the development of rings and spheres from nebulous masses.

The second part is an exceedingly profitable discussion of the origin of the solar system, in which the nebular theory is strongly supported by facts, and the objections urged against it are set forth, such as those based on the relations

of planetary motions, the relations of planetary positions, the relations of planetary masses and densities, the relation to terrestrial duration, relations of comets, stars and nebulae, what the nebular theory does not imply, and modified forms of the theory. The condition on a cooling planet is next considered, beginning with the relative ages of planets, passage to the molten phase, superficial solidifying from cooling, internal solidifying from pressure, maximum internal temperature on an incrustated planet, tidal action and its consequences, liquefaction of water, transformations of the planetary crust, effects of certain varied astronomical conditions, such as changes in the velocity of rotation, retarded orbital motion, increase of the obliquity of the axis of a planet, change of the relative positions of apsis line and equinoxes and changes of orbital eccentricity.

Then follow particular studies of the *Earth*, *Moon*, *Mars*, superior planets, *Jupiter* and the ultra-jovian planets. The concluding chapters of this part on planetary decay and the habitability of other worlds contain the gist of late research and much that will interest the student of astronomy. Part third deals with the origin of the fixed stars and nebulae, in which double, triple and multiple stars, temporary stars, gradation of stars, and the indications of incipient stellation are particularly noticed. Finally, in part fourth, we have grouped together the opinions of philosophers from ancient times, touching the origin of worlds and the structure of the universe, and kindred speculations, including the researches of Sir WM. HERSCHEL and LA PLACE's system of the world. From a glance at this brief and incomplete outline of the contents of this book, any scholar will notice a range of thought unusually wide, and an aim to wrestle with the leading scientific questions of the day. A perusal of the book has led the writer to think that it is one of the most important contributions to science that has appeared in America, at least for years.

The work is published by Messrs. S. C. Griggs & Co., Chicago, is neatly illustrated, contains 642 pages and costs at retail, \$2.50.

## MINOR PLANET HERCHA.

Made at the National Observatory, Washington, with the 9.6-inch Equatorial by W. T. SAMPSON.

Communicated by Rear-Admiral Shufeldt, Supt.

1883	Wash. M. T.	Hercha—Star		No. of Comp	Star a app.	log (p×Δ)	Hercha δapp	log (p×Δ)	Comp Star.
		Δ α	Δ δ						
		h m s	m s		h m s		° ′ ″		
Oct.	24	11 12 51.36	-1 16.31	20.4	2 24 21.56	9.08712 <sub>n</sub>	17 48	2.50	50811
	26	9 4 35.95	+0 45.75	20.4	2 22 21.79	9.52790 <sub>n</sub>	17 39 53	6.0	57618
	29	11 20 21.72	-2 28.57	20.4	2 19 7.48	8.73927 <sub>n</sub>	17 26 23	2.0	50765
	30	9 42 52.12	-3 26.76	15.3	2 18 9.29	9.88323 <sub>n</sub>	17 22 12	1.0	54240
	31	8 35 49.69	+0 33.83	15.3	2 17 10.79	9.53454 <sub>n</sub>	17 17 52	9.0	58371
Nov.	1	9 26 39.42	-0 30.02	20.4	2 16 6.95	9.39842 <sub>n</sub>	17 13 10	8.0	54832
	3	7 18 29.35	+1 13.71	20.4	2 14 5.48	9.39267 <sub>n</sub>	17 3 53	2.0	54976
	3	9 18 29.35	+1 13.71	20.4	2 14 5.23	"	17 3 53	"	"
	4	8 32 57.34	+0 15.57	20.4	2 13 7.35	9.49960 <sub>n</sub>	16 59 20	6.0	55242
	5	10 18 33.74	-0 48.04	20.4	2 12 3.76	9.04561 <sub>n</sub>	16 54 17	5.0	52324
	17	7 33 28.93	-4 24.29	15.3	2 1 46.62	9.47092 <sub>n</sub>	16 0 36	5.0	58682
	19	10 27 44.14	+3 43.09	15.3	2 0 16.31	8.67482 <sub>n</sub>	15 52 30	0.0	53632
Star		α	δ			Authority			
		1883.0	1883.0						
		h m s	° ′ ″						
1		2 56 33.16	17 51 20.3	W. 582					
2		2 21 31.30	17 33 3.1	W. 477					
3		2 16 32.23	17 3 48.4	W. 356					
4*		2 12 47.01	17 6 14.1	W. 262					
5		2 6 6.14	16 8 37.6	W. 85					
6		1 56 28.38	16 5 55.8	W. 1311					

\*The position given in W. is in error - 21" .5 in dec. for 1883.

Washington T. circle for declination  
Washington T. circle for declination

## EDITORIAL NOTES.

This number ends Vol. II of the MESSENGER. Vol. III will contain ten numbers of at least thirty-two pages each, and will be completed within the year, that subsequent volumes may start always at the beginning of the year.

Any person desiring the first three volumes of the *Observatory*, (English) bound, can be accommodated at reasonable price, as we have duplicate copies by purchase accidentally.

Volumes I or II of the MESSENGER, bound neatly in library style, will be sent to any address on receipt of \$2.50 for each volume and fifteen cents extra for postage when necessary.

The annual report of Professor G.W. HOUGH, Director of Dearborn Observatory, Chicago, has points of special interest concerning the great comet of 1882, difficult double-stars, the planet *Jupiter* and miscellaneous observations. Observations on the great comet extended from October 4, to March 6, 1883. In October, it was thought by some observers, that the nucleus was broken into three distinct fragments. Professor HOUGH thinks there was no actual separation: there were three centers of condensation observable in the nucleus, October 5 and 6, but these centers were always connected by matter of less density. October 4, the actual length of the nucleus and envelope was 13,500 miles, its breadth nearly 5,000 miles. The tail in moonlight could be traced 25° corresponding to 50 millions of miles.

During the past four years, the principal object of interest has been the great red spot first noticed in 1878. It was formerly of a reddish brick color, since, it has been growing paler, and in May last it was barely visible. It will doubtless soon disappear entirely. This spot has been remarkably stable. Since, 1879, it has not changed in length, breadth, outline nor altitude. There has been a slow retrograde drift in longitude which of course increases the apparent rotation time of the planet. The approximate mean at last opposition was  $9^h 55^m 38.4^s$  showing that the drift continues. The detailed study of the belts and spots on the disc of *Jupiter* is instructive, and, in connection with previous work done by Professor HOUGH furnishes doubtless, the most complete and reliable information concerning the physical state of the planet's disc now on record. These special studies as before, are illustrated neatly by full page drawing which are tinted to represent the telescopic view of the parts under consideration.

## PONS (1812) COMET.

At the regular meeting of the California Academy of Sciences held

in San Francisco, December 3rd, Prof. AVIDSON, the president, stated that at 8 p. m. of the 1st, the Pons comet of 1812 was distinctly visible to the unassisted eye. It is believed this is the first time it has been seen without artificial aid. In the telescope (6.4 inches) the nucleus at times showed as a bright center, but not nearly so bright, nor of the same character, as a very small star near it which suffered little or no change in its constancy. Since that date the moonlight has prevented the comet being seen by the naked eye, but observations have been made upon it.

In *Knowledge*, (July 13, 1883), the Editor referring to Dr. HASTINGS' view, that the outer parts of the solar corona are merely a phenomenon of diffraction, calls it an "absurdity to which he is said to have committed himself, at which I imagine those among his fellow-workers in America who are competent to form an opinion, as Professors YOUNG, NEWCOMB and LANGLEY will be disposed to smile." At the November meeting of the National Academy of Science, in New Haven, Dr. HASTINGS read, an elaborate paper on the solar corona, as his report of the solar eclipse expedition to Caroline Island in which he advocated the diffraction theory. In the discussion of this which followed, Professor YOUNG is reported to say, "that the theory of diffraction of solar light, and the mathematical arguments based on the equations of Fresnel were to him valuable and interesting. If not altogether true, the theory contained so much of truth, that it must be treated with respect, and could not possibly be ignored by any inquirer." The trouble with American astronomers generally now is they do not know whether to smile or not at Professor HASTINGS' "absurdity," because the above named gentleman have not smiled.

This day we do also remember our faults, in not gracefully acknowledging the lengthy compliment paid to the MESSENGER by the same issue of *Knowledge* above referred to in regard to borrowed articles. It ought not to be necessary to tell *Knowledge* a second time that its statements are untrue. It is a fact that all the articles of the MESSENGER referred to were prepared by their authors for it, and set from their manuscript and nowhere else printed before, except those entitled "Recent contributions to our knowledge of the Moon," "The Earth," and "When will the comet return," amounting in all to about eight pages out of thirty-four. This being true *Knowledge* has no right to say that the matter of that issue was "chiefly borrowed articles." That was a provoking breach of courtesy, and by no means atoned for by saying later, that the MESSENGER "is a very useful publication." However, with its occasional faults, to be expected in any vigorous magazine, we cheerfully say *Knowledge* is one of the best scientific papers in the world.

A BABYLONIAN TABLE OF SQUARES.

This interesting specimen of ancient arithmetic was recently sent us by Professor HAGAN, S.J. College of the Sacred Heart, Prairie du Chien Wis. It can be easily read throughout, by giving a moments attention to the words above the columns and the characters. It runs thus:  $1=1^2$   $4=2^2$ ;  $9=3^2$ ;  $16=4^2$ , etc.

Professor HAGAN says respecting the table. "I enclose the copy of a tablet on cuniform inscriptions which was taken by a member of the Oriental society, from the British Museum, London. The original was found by Loftus, in Warkah, and is supposed to be of the 7th or 8th century B. C. \* \* \*. Your paper is read with great interest by the professors and students of our college."

PERSONAL.

Professor C. S. HASTINGS has resigned his position at Johns Hopkins university. It is reported that he goes to Yale college next year.

WINSLOW UPTON of the chief signal office, Washington, D. C. has accepted the position of professor of astronomy in Brown university. That institution will build an observatory and equip it, thus furnishing Mr. UPTON needed facilities for instruction and original work.

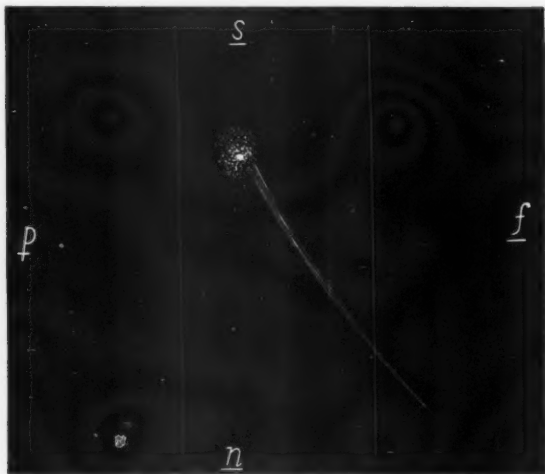
Professor H. A. HOWE, of Denver university, now has a five-inch telescope in working order. It was purchased recently from funds raised by personal solicitation. It is gratifying to know that Mr. Howe has already the coveted telescope in hand. So competent an observer as he should not be idle.

H. E. MATHEWS, Secretary of the James Lick Trust, has kindly sent us a clear and beautiful photographic view of Mt. Hamilton, Cal., the site of Lick observatory. The picture was taken by Mr. MATHEWS, while on a recent visit to the observatory, and it gives a distant, front view of the summit and the observatory building, (small scale), surmounting it, with the circling carriage way leading to it, known as Lick avenue.

\* Probably.

sixteen.	Pens.	Units.	Not intelligible	Pens.	Units
1	1	1	1	1	1
4	4	4	4	4	4
9	9	9	9	9	9
16	16	16	16	16	16
25	25	25	25	25	25
36	36	36	36	36	36
49	49	49	49	49	49
64	64	64	64	64	64
81	81	81	81	81	81
100	100	100	100	100	100
121	121	121	121	121	121
144	144	144	144	144	144
169	169	169	169	169	169
196	196	196	196	196	196
225	225	225	225	225	225
256	256	256	256	256	256
289	289	289	289	289	289
324	324	324	324	324	324
361	361	361	361	361	361
400	400	400	400	400	400
441	441	441	441	441	441
484	484	484	484	484	484
529	529	529	529	529	529
576	576	576	576	576	576
625	625	625	625	625	625
676	676	676	676	676	676
729	729	729	729	729	729
784	784	784	784	784	784
841	841	841	841	841	841
900	900	900	900	900	900
961	961	961	961	961	961
1024	1024	1024	1024	1024	1024
1089	1089	1089	1089	1089	1089
1156	1156	1156	1156	1156	1156
1225	1225	1225	1225	1225	1225
1296	1296	1296	1296	1296	1296
1369	1369	1369	1369	1369	1369
1444	1444	1444	1444	1444	1444
1521	1521	1521	1521	1521	1521
1600	1600	1600	1600	1600	1600
1681	1681	1681	1681	1681	1681
1764	1764	1764	1764	1764	1764
1849	1849	1849	1849	1849	1849
1936	1936	1936	1936	1936	1936
2025	2025	2025	2025	2025	2025
2116	2116	2116	2116	2116	2116
2209	2209	2209	2209	2209	2209
2304	2304	2304	2304	2304	2304
2401	2401	2401	2401	2401	2401
2500	2500	2500	2500	2500	2500
2601	2601	2601	2601	2601	2601
2704	2704	2704	2704	2704	2704
2809	2809	2809	2809	2809	2809
2916	2916	2916	2916	2916	2916
3025	3025	3025	3025	3025	3025
3136	3136	3136	3136	3136	3136
3249	3249	3249	3249	3249	3249
3364	3364	3364	3364	3364	3364
3481	3481	3481	3481	3481	3481
3600	3600	3600	3600	3600	3600
3721	3721	3721	3721	3721	3721
3844	3844	3844	3844	3844	3844
3969	3969	3969	3969	3969	3969
4096	4096	4096	4096	4096	4096
4225	4225	4225	4225	4225	4225
4356	4356	4356	4356	4356	4356
4489	4489	4489	4489	4489	4489
4624	4624	4624	4624	4624	4624
4761	4761	4761	4761	4761	4761
4900	4900	4900	4900	4900	4900
5041	5041	5041	5041	5041	5041
5184	5184	5184	5184	5184	5184
5329	5329	5329	5329	5329	5329
5476	5476	5476	5476	5476	5476
5625	5625	5625	5625	5625	5625
5776	5776	5776	5776	5776	5776
5929	5929	5929	5929	5929	5929
6084	6084	6084	6084	6084	6084
6241	6241	6241	6241	6241	6241
6400	6400	6400	6400	6400	6400
6561	6561	6561	6561	6561	6561
6724	6724	6724	6724	6724	6724
6889	6889	6889	6889	6889	6889
7056	7056	7056	7056	7056	7056
7225	7225	7225	7225	7225	7225
7396	7396	7396	7396	7396	7396
7569	7569	7569	7569	7569	7569
7744	7744	7744	7744	7744	7744
7921	7921	7921	7921	7921	7921
8100	8100	8100	8100	8100	8100
8281	8281	8281	8281	8281	8281
8464	8464	8464	8464	8464	8464
8649	8649	8649	8649	8649	8649
8836	8836	8836	8836	8836	8836
9025	9025	9025	9025	9025	9025
9216	9216	9216	9216	9216	9216
9409	9409	9409	9409	9409	9409
9604	9604	9604	9604	9604	9604
9801	9801	9801	9801	9801	9801
10000	10000	10000	10000	10000	10000

J. R. Hooper, of Baltimore kindly furishes a sketch of the Pons-Brooks comet as observed by him Dec. 17, at 7 o'clock in the evening. The streamer was curved on the following side which was denser than the other. It could be traced one and one-third degrees in length.



THE BROOKS' COMET.

The tail of the comet is not visible to the naked eye, though, recently it has been easily seen in the telescope. Any person knowing where to look can easily find it. It is moving south and east through the *Milky Way* and is at a small distance south-east of the star Epsilon *Cygni*, the most southern star in the arm of the *Cross*. The appearance of the comet is but a dim patch of light. It will be brightest about the middle, or latter part of January, for the computers do not agree.

Professor DAVIDSON, of the United States Coast Survey, San Francisco, calls attention to a wrongly reported observation as follows:

On page 284, of the MESSENGER, the time of the commencement is erroneous; it should be  $3^h 46^m 14.5^s$ , observer, DAVIDSON: Instrument Equatorial 6.4 inches. Airy double image micrometer power, about 240. Professor C. B. HILL observed with a three-inch portable telescope, and was 2.6<sup>s</sup> later than the above time. Instead of being six minutes later than the predicted time—the observed time was eight seconds later.

## ELEMENTS OF PONS-BROOKS' COMET.

$T$	Jan. 26 042.
$\pi$	$97^{\circ} 18' 1.63''$
$\Omega$	$257^{\circ} 47' 34.21''$
$i$	$73^{\circ} 45' 57.97''$
$\omega$	$199^{\circ} 30' 27.42''$
$\varphi$	$74^{\circ} 17' 11.01''$
Log ( $i - e$ )	8.5725533
Log $a$	1.3146130
Log $q$	9.8871663

These elliptical elements are based on the observations of Sept. 23, Oct. 29, Oct. 31, 1883.

PROVIDENCE, R. I. Dec. 12, 1883.

F. E. SEAGRAVE.

Mr. CHARLES H. ROCKWELL, Tarrytown, N. Y., recently visiting Harvard college observatory, saw the working of the new instrument, called the "Almacantar," in the hands of its inventor, Mr. S. C. CHANDLER, and he was so well satisfied with its efficiency that he ordered one for his own use. The telescope is to be four inches aperture and forty inches focal length, and the instrument, complete will cost about \$500.

The last MESSENGER contains a carefully written article, descriptive of this new instrument and its work, the results of which were surprisingly accurate in view of the size of the instrument, to say nothing of the rude way in which the first one was made, being designed chiefly for the purpose of testing the new theory on which the instrument works. The "Almacantar" is attracting the attention of some of our best observers who appear to have full confidence in the working of the new principle already.

The Vanderbilt university, Nashville, Tenn., in a recent order of books received a second hand copy of BESSEL'S "Tabulae Regiomontanae," edition of 1830. Upon a fly leaf of this old book is inscribed in fair hand writing, *Seinem theuern und hochgeschätzten Freunde*, Encke der Verfusser. Translated:—To his dear highly and prized friend, ENCKE, the author.

This shows the book to have been ENCKE'S own copy which had been presented to him by BESSEL. There is some writing on the back in beautiful German characters, but it is too much mutilated to translate.

E. E. B.

Capt. R. S. FLOYD, Prest. of the Board of Trustees is at Mt. Hamilton, personally supervising the work of construction in which he is zealously interested.

## THE TOOLS OF THE ASTRONOMER.

The "Jesuit sermon" mentioned on page 268, (last MESSENGER) was not preached by a Jesuit, but by a Dominican friar of the name Caccini, in the Advent of 1624. In order to do justice both to Caccini and to his Order, it must be added, that he himself asked pardon of Galileo, and that the Superior General of the Order, Luigi Maraffi, addressed a letter of excuse to Galileo in which he says:—"I feel very sorry for the scandal that has happened,—so much the more as the author is one of my brethren; it is very trying that I should be held responsible for all the excesses, that may be, and are, committed by from thirty to forty thousand brethren."

## COLLEGE OF THE SACRED HEART.

It may interest the readers of your valuable paper to learn that our college has just completed a dome of thirteen feet diameter. Its plan which has been taken from the publications of the Washburn observatory, Madison, was executed after a personal inspection of the Students' observatory there, while on a visit to its director Professor EDWARD S. HOLDEN. The small equatorial is chiefly devoted to the observation of variable stars which are made in connection with the Harvard College observatory.

A large pier, ten feet high, has also been erected in one of the windows for observations on gravitation.

J. HAGAN, S. J.

## BOOK NOTICE.

Oppolzer; Lehrbuch zur Bahnbestimmung der Kometen und Planeten, Band II. Wilhelm Engelmann, Leipzig.

Lately a review of Vol. I. of this work appeared in these columns; as many of our readers may not be acquainted with Vol. II, which is devoted to the computation of perturbations, etc., we present a short review of it.

The book is divided into four sections. The first section treats of numerical differentiation and integration, including both single and double integration, illustrated by numerous examples. The second section is occupied by the computation of special perturbations, Encke's method, Tietjens' modification of Hansen's method, and the method of the variation of constants are all explained, and a very full numerical computation, covering the entire work, accompanies each. The conclusion reached is that for a limited time, such as the time of appearance of a comet or the opposition of an asteroid, Encke's method is the best, and Tietjen's next. If, however the time is long, it would be necessary, in Encke's method, to make frequent transformations to osculating elements; then variation of the constants is preferable; only in the case of an orbit of great eccentricity does Tietjen's method take the first rank.

The third section is devoted to the method of least squares. [H. A. H.

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